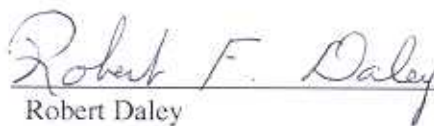


CRITERION 511

STATIONARY SYSTEM BATTERIES

SIGNATURES

Robert Daley
Criterion Author2/13/03

Date

FWO-SEM

Group

667-8882

Phone Number

David McIntosh
Maintenance Engineering Team Leader2-12-03

Date

FWO-SEM

Group

667-3616

Phone Number

Kurt Beckman
Acting Group Leader2/13/03

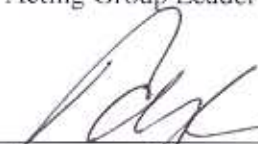
Date

FWO-SEM

Group

667-6261

Phone Number

Facility Management Council
Committee Chairperson2-27-03

Date

FWO

Group

667-9364

Phone Number

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CRITERION 511

STATIONARY SYSTEM BATTERIES

1.0 PURPOSE

The primary purpose of this criterion is to establish the minimum requirements and best practices for a Battery Maintenance Program to ensure that the battery installations are able to meet the emergency requirements of the system.

This document addresses the requirements of LIR 230-05-01, "Operations and Maintenance Manual." (Ref. 10.1) This document addresses the contractual requirement to "maintain physical assets in a condition suitable for their intended purpose." It defines a process for operations and maintenance of the subject systems or components that will implement, "The preventive, predictive, and corrective maintenance to ensure physical asset availability for planned use and/or proper disposition." (DOE O 430.1A, Attachment 2, "Contractor Requirements Document," Paragraph 2, Sections A through C). (Ref. 10.2) The requirements and recommendations of this criterion apply to all Laboratory stationary system batteries, both RP&IE and PP&PE, which is required by Appendix G of the UC/DOE contract.

2.0 SCOPE

The scope of this Criterion includes the inspecting, testing, and maintaining of large stationary system batteries at scheduled intervals in accordance with the requirements of DOE, LANL and NFPA regulations and the recommendations of IEEE standards. Requirements and recommendations were obtained from the standards listed in Section 10.0, References.

The batteries covered are lead-acid and nickel-cadmium types only. The systems include battery banks for emergency lighting (excluding unit equipment covered in Criterion 503 Emergency Lighting); for UPS (additional detail beyond that of Criterion 505 UPS); and for the starting, controlling or igniting of engines powering generators, pumps, etc. (including those covered by Criterion 506 Standby Power). (References 10.14, 10.15 and 10.16)

Small sealed nonmaintainable batteries (e.g., D cells) are not included.

The requirements and recommendations of this Criterion apply to all Laboratory emergency system batteries, both Real Property & Institutional Equipment (RP&IE) and Personal Property & Programmatic Equipment (PP&PE). This Criterion does not address corrective maintenance actions required to repair or replace equipment.

3.0 ACRONYMS AND DEFINITIONS

3.1 Acronyms

AHJ	Authority Having Jurisdiction
AR	Administrative Requirements
ANSI	American National Standards Institute
ASTM	American Society for Testing and Material
CFR	Code of Federal Regulations
CMMS	Computerized Maintenance Management System
IEEE	Institute of Electrical and Electronic Engineers
ISEA	Industrial Safety Equipment Association
LIR	Laboratory Implementing Requirement
LIG	Laboratory Implementing Guidance
LPR	Laboratory Performance Requirement
NFPA	National Fire Protection Association
NSC	National Safety Council
O&M	Operations and Maintenance
OEWS	Operating Experience Weekly summary (DOE Lessons Learned)
PPE	Personal Protective Equipment
PP&PE	Personal Property and Programmatic Equipment
RAD	Radiation Absorbed Dose
RP&IE	Real Property and Installed Equipment
SSC	Structures, Systems, and Components
TFE	Tetrafluoroethylene (e.g., Teflon™)
UC	University of California

3.2 Definitions

Battery. Two or more cells electrically connected for producing electric energy. (IEEE 446-2.2). (Ref. 10.5)

Battery Rack. A structure used to support a group of cells. (IEEE 446, Section 2.2). (Ref. 10.5)

Cell. The basic electrochemical unit, characterized by an anode and a cathode used to receive, store, and deliver electrical power. (IEEE 100, Section 2). (Ref. 10.6)

Charger. Static equipment that is capable of restoring and maintaining the charge in a storage battery (IEEE 100). (Ref. 10.6)

Duty Cycle. The load currents a battery is expected to supply for specified time periods. (IEEE 450, Section 3) (Ref. 10.7)

Equalizing Charge. A charge applied to a battery, which is greater than the normal float charge and is used to completely restore the active materials in the cell, bringing the cell float voltage and the specific gravity of the individual cells back to equal values. (DOE 3003, Section 3) (Ref. 10.10)

Float Voltage. The voltage applied to a battery to maintain it in fully charged condition during normal operation. (IEEE 450, Section 3). (Ref. 10.7)

Level 1. The most stringent equipment performance requirements for applications where failure of the equipment to perform could result in loss of human life or serious injury. Level 1 systems are intended to automatically supply illumination or power, or both, to critical areas and equipment in the event of failure of the primary supply. Level 1 systems provide power for illumination and ventilation when essential to maintain life, fire detection and alarm systems, elevators, fire pumps, public safety communications system, industrial processes where current interruption would produce serious life safety or health hazards. An example of Level 1 batteries is a battery bank feeding multiple emergency lights. (NFPA 110, Sections 2-1 & A-2-2.4.1). (Ref. 10.9)

Level 2. Level 2 systems supply power automatically to selected loads (other than those classed as emergency systems) in the event of failure of the primary source. Level 2 systems typically are installed to serve loads such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewerage disposal, lighting, and industrial processes that, when stopped due to any interruption of the primary electrical supply, could create hazards or hamper rescue or fire-fighting operations. (NFPA 110, Section A-2-2.4.2) (Ref. 10.9)

Nickel-cadmium Battery. An alkaline storage battery in which the positive active material is nickel oxide and the negative contains cadmium. (IEEE 100). (Ref. 10.6)

Performance Test. A constant current or constant power capacity test, made on a battery after it has been in service, to detect any change in the capacity. (IEEE 450, Section 3) (Ref. 10.7)

Service Test. A test, in the “as found” condition, of the battery’s capability to satisfy the battery duty cycle. (IEEE 450, Section 3). (Ref. 10.7)

Stationary Battery. A storage battery designed for service in a permanent location. (IEEE100) (Ref. 10.6)

Valve-regulated Lead-acid Cell. A cell that is sealed with the exception of a valve that opens to the atmosphere when the internal gas pressure in the cell exceeds atmospheric pressure by a preselected amount. (IEEE 446, Section 2.2). (Ref. 10.5)

Vented Cell. A cell in which the products of electrolysis and evaporation are allowed to escape to the atmosphere as they are generated. (IEEE 446, Section 2.2). (Ref. 10.5)

4.0 RESPONSIBILITIES

4.1 FWO-Systems, Engineering and Maintenance (SEM)

- 4.1.1** FWO-SEM is responsible for the technical content of this Criterion and monitoring the applicability and the implementation status of this Criteria and either assisting the organizations that are not applying or meeting the implementation expectations contained herein or elevating their concerns to the director(s).

Basis: LIR 301-00-01.11; Issuing and Managing Laboratory Operations Implementation Requirements and Guidance, Section 5.4, OIC Implementation Requirements.

- 4.1.2** FWO-SEM shall provide technical assistance to support implementation of this Criterion.

4.2 Facility Manager

- 4.2.1** Responsible for operations and maintenance of institutional, or Real Property and Installed Equipment (RP&IE) under their jurisdiction, in accordance with the requirements of this document.

- 4.2.2** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that may be assigned to the FM in accordance with the FMU-specific Facility/Tenant Agreement.

4.3 Group Leader

- 4.3.1** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that are under their jurisdiction

- 4.3.2** Responsible for system performance analysis and subsequent replacement or refurbishment of assigned PP&PE.

4.4 Authority Having Jurisdiction (AHJ) - POC for Electrical Chapter of LANL Engineering Manual

- 4.4.1** The AHJ is responsible for providing a decision on a specific technical question regarding this criterion..

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Precautions

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion. A compilation of all applicable precautions shall be contained in the implementing procedure(s) or work control authorization documents. The following precautions are intended only to assist the author of a procedure or work control document in the identification of hazards and precautions that may not be immediately obvious.

- 5.1.1** A one-gallon quantity of acid neutralizing agent must be at the work site. A solution of one pound of bicarbonate of soda in one gallon of water is recommended for lead-acid batteries. A solution of one pound of boric acid in one gallon of water is recommended for nickel-cadmium batteries.
- 5.1.2** All tools used on the batteries must be listed as nonconductive or have insulated handles.
- 5.1.3** A non-CO2 Class C fire extinguisher must be at the work site – the extinguishing agent must not interact with sulfuric acid (ammonium phosphate recommended).
- 5.1.4** No smoking or open flames within 10 feet of the batteries.
- 5.1.5** Insure that load test leads are clean, in good condition with a sufficient length of cable to prevent arcing in the vicinity of the batteries.
- 5.1.6** All connections to load test equipment must include short circuit protection.
- 5.1.7** Before starting work verify that ventilation equipment is working in battery room.
- 5.1.8** Ensure unobstructed egress from battery area toward eyewash station and room exit.
- 5.1.9** Workers should neutralize static buildup by grounding themselves before nearing batteries.
- 5.1.10** Disconnect charging sources and loads prior to opening or closing any battery connection.

5.2 Limitations

The intent of this Criterion is to identify the minimum generic requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility-specific requirements and recommendations based on their authorization basis and

unique equipment and conditions, (e.g., equipment history, manufacturer warranties, operating environment, vendor O&M requirements and guidance, etc.).

Nuclear facilities and moderate to high-hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion. Nuclear facilities shall implement the requirements of DOE Order 4330.4B (Ref. 10.3) as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or CFR identified above.

6.0 REQUIREMENTS

Minimum requirements that Criterion users shall follow are specified in this section. Requested variances to these requirements shall be prepared and submitted to FWO-SEM in accordance with LIR 301-00-02 (Ref. 10.4), "Variances and Exceptions to Laboratory Operations Requirements," for review and approval. The Criterion users are responsible for analysis of operational performance and SSC replacement or refurbishment based on this analysis. Laws, codes, contractual requirements, engineering judgement, safety matters, and operations and maintenance experience drive the requirements contained in this section.

6.1 Operations Requirements

- 6.1.1 Ensure workers performing inspection, testing, and/or maintenance of batteries have appropriate full eye protection – goggles or face shield.
- 6.1.2 Ensure workers performing inspection, testing, and/or maintenance of batteries to have appropriate protective acid resistant clothing – gloves, aprons, and overshoes.
- 6.1.3 Ensure that a portable or stationary safety shower and eye wash station is located within 25 feet of the batteries for workers performing inspection, testing, and/or maintenance of batteries.

Basis: 29 CFR 1926.441(a)(5) require these items. (Ref. 10.19) (Compliance with this code is required per Appendix G of the UC Contract)

6.2 Maintenance Requirements

6.2.1 Vented Lead-Acid Batteries

- 6.2.1.1 Perform maintenance of lead-acid batteries in accordance with Appendix A.

Basis: DOE Order 430.1A, Attachment 2, Contractor Requirements Document (Ref. 10.2), requires maintenance of physical assets to ensure assets are available and in a condition suitable for planned use. Appendix A lists maintenance tasks and the schedules for performing these tasks, which are

required by NFPA-110, NFPA-111, and recommended by IEEE 450. (References 10.9, 10.13, 10.7)

NFPA-110, Section 6-3.6 requires visual inspection of Level 1 and Level 2 storage batteries at intervals of not more than 7 days. NFPA-110, Sections 6-1.1 and 6-3.6 require maintenance of Level 1 and Level 2 storage batteries in full compliance with manufacturer's specifications. (Ref. 10.9) NFPA-111, Section 6-4 requires Level 1 battery systems to be load service tested for 5 minutes every quarter and for the full duty cycle annually. (Ref. 10.13) (Compliance with these NFPA codes is required per Appendix G of the UC Contract.)

IEEE 450 (Ref. 10.7) is an industry standard which forms the basis of manufacturers' specifications for all vented lead-acid cells. The recommendations of IEEE 450 are listed in Appendix A to provide direction for meeting the requirements of DOE Order 430.1A, NFPA-110, and NFPA-111. (References 10.2, 10.9, 10.13)

- 6.2.1.2** Replace or repair Level 1 and Level 2 lead-acid batteries immediately (i.e. prior to placing back in service) upon discovery of defects. Refer to Appendix A, for descriptions of defects.

Basis NFPA-110, Section 6-3.6 (Ref. 10.9) requires Level 1 and Level 2 batteries to be immediately repaired or replaced upon discovery of defects. (Compliance with NFPA-110 is required per Appendix G of the UC Contract.)

IEEE 450, Section 4.4.1 (Ref. 10.7) describes the types of defects requiring immediate actions. This IEEE document is an industry standard for vented lead-acid batteries and provides direction for meeting the requirements of NFPA-110.

DOE-STD-3003-2000, Section 5.4.2.2 (Ref. 10.10), states that battery replacement criteria for lead-acid cells shall be in accordance with IEEE 450.

6.2.2 Valve-Regulated Lead-Acid Batteries

- 6.2.2.1** Perform maintenance of valve-regulated lead-acid batteries in accordance with Appendix B.

Basis: DOE Order 430.1A, Attachment 2, Contractor Requirements Document (Ref. 10.2), requires maintenance of physical assets to ensure assets are available and in a condition suitable for planned use. Appendix B lists maintenance tasks and the schedules for performing these tasks which are

required by NFPA-110, NFPA-111 and recommended by IEEE 1188. (References 10.9, 10.13, 10.12)

NFPA-110, Section 6-3.6, requires visual inspection of Level 1 and Level 2 storage batteries at intervals of not more than 7 days. NFPA-110, Sections 6-1.1 and 6-3.6 require maintenance of Level 1 and Level 2 storage batteries in full compliance with manufacturer's specifications. (Ref. 10.9) NFPA-111, Section 6-4 requires Level 1 battery systems to be load service tested for 5 minutes every quarter and for the full duty cycle annually. (Ref. 10.13) (Compliance with these NFPA codes is required per Appendix G of the UC Contract.)

IEEE 1188 (Ref. 10.12) is an industry standard which forms the basis of manufacturers' specifications for all valve-regulated lead-acid cells. The recommendations of IEEE 1188 are listed in Appendix B to provide direction for meeting the requirements of DOE Order 430.1A, NFPA-110, and NFPA-111. (References 10.2, 10.9, 10.13)

- 6.2.2.2** Replace or repair Level 1 and Level 2 valve-regulated lead-acid batteries immediately (prior to placing back in service) upon discovery of defects. Refer to Appendix B for defects requiring immediate replacement or repair of batteries.

Basis: NFPA-110, Section 6-3.6 (Ref. 10.9) requires Level 1 and Level 2 batteries to be immediately repaired or replaced upon discovery of defects. (Compliance with NFPA-110 is required per Appendix G of the UC Contract.)

IEEE 1188, Section 5.3.1 (Ref. 10.12) describes the types of defects requiring immediate actions. This IEEE document is an industry standard for valve-regulated lead-acid batteries and provides direction for meeting the requirements of NFPA-110.

6.2.3 Nickel-Cadmium Batteries

- 6.2.3.1** Perform maintenance of nickel-cadmium batteries in accordance with Appendix C.

Basis: DOE Order 430.1A, Attachment 2, Contractor Requirements Document (Ref. 10.2), requires maintenance of physical assets to ensure assets are available and in a condition suitable for planned use. Appendix C lists maintenance tasks and the schedules for performing these tasks required by NFPA-110, NFPA-111 and recommended by IEEE 1106. (References 10.9, 10.13, 10.11)

NFPA-110, Section 6-3.6 requires visual inspection of Level 1 and Level 2 storage batteries at intervals of not more than 7 days. NFPA-110, Sections 6-1.1 and 6-3.6 requires maintenance of Levels 1 and 2 storage batteries in full compliance with manufacturer's specifications. (Ref.

10.9) NFPA-111, Section 6-4 requires Level 1 battery systems to be service tested for 5 minutes every quarter and for the entire duty cycle annually. (Ref. 10.13) (Compliance with these NFPA codes is required per Appendix G of the UC Contract.)

IEEE 1106 (Ref. 10.11) is an industry standard which forms the basis of manufacturers' specifications for all nickel-cadmium cells. The recommendations of IEEE 1106 are listed in Appendix C to provide direction for meeting the requirements of DOE Order 430.1A, NFPA-110 and NFPA-111. ((References 10.2, 20.9, 10.13)

- 6.2.3.2** Replace or repair Level 1 and Level 2 nickel-cadmium batteries immediately upon discovery of defects. Refer to Appendix C for defects requiring immediate replacement or repair of batteries.

Basis: NFPA-110, Section 6-3.6 (Ref. 10.9) requires Level 1 and Level 2 batteries to be immediately repaired or replaced upon discovery of defects. (Compliance with NFPA-110 is required per Appendix G of the UC Contract.)

IEEE 1106, Section 7.3.1 (Ref. 10.11) describes the types of defects requiring immediate actions. This IEEE document is an industry standard for nickel-cadmium batteries and provides direction for meeting the requirements of NFPA-110. (Ref. 10.9)

DOE-STD-3003-2000, Section 5.4.2.2 (Ref. 10.10), states that battery replacement criteria for nickel-cadmium cells shall be in accordance with IEEE 1106. (Ref. 10.11)

7.0 RECOMMENDATIONS AND GOOD PRACTICES

The information provided in this section is recommended based on acceptable industry practices and should be implemented by each user based on his / her unique application and operating history of the subject systems / equipment.

7.1 Operations Recommendations

- 7.1.1** Attempt to provide optimum environmental conditions for the operation of batteries. If the design temperature is unknown assume a temperature of 77°F.

Basis: IEEE 446-8.6.1 (Ref. 10.5) states that higher than design temperatures will reduce battery life, while lower than design temperatures will reduce battery capacity.

7.2 Maintenance Recommendations

- 7.2.1** Equalizing charges should be periodically applied, per manufacturer's recommendation, to equalize cell voltages. (Charging will typically require between 35 and 70 hours.)

Basis: DOE STD 3003-5.4.2 (Ref. 10.10) suggests that even batteries that are continually floated by a battery charger may need periodic equalizing to maintain the batteries' charge.

- Equalizing charging should not be performed unless specifically recommended by the manufacturer for valve-regulated lead-acid batteries.

IEEE 1188-D.3 (Ref. 10.12) discusses the fact that different types of batteries require different types of charging. Over-charging batteries may create excessive off gassing. This may damage seals in some types of batteries (e.g. valve-regulated lead-acid batteries).

8.0 GUIDANCE

8.1 Operations Guidance

- 8.1.1** Appendix D lists standards that provide information on selecting proper personnel protective equipment to meet the requirements of Section 6.1 of this Criterion.

8.2 Maintenance Guidance

- 8.2.1** Methods for performing the maintenance tasks listed in Appendices A, B, and C and defined acceptable results can be found in manufacturer's maintenance manuals.
- 8.2.2** Provided it has been reviewed and approved by FWO-SEM, information on maintaining stationary batteries may be found in the JCNNM preventive maintenance instructions; PMI 40-10-003 (Battery Bank Preventive Maintenance and Inspection) (Ref. 10.18) and PMI 40-10-010 (Nickel-cadmium Battery Bank Preventive Maintenance and Inspection) (Ref. 10.17).

9.0 REQUIRED DOCUMENTATION

Maintenance history shall be maintained by FM for batteries to include, as a minimum, the parameters listed in the Table 9-1 below:

Table 9-1 Documentation Parameters

MAINTENANCE HISTORY DOCUMENTATION PARAMETERS				
PARAMETER	ML 1	ML 2	ML 3	ML 4
Maintenance Activities				
Repair / Adjustments	X	X	X	X
PM Activities	X	X	X	
Equipment Problems				
Failure Dates	X	X	X	
Failure Root Cause	X	X		
Inspection Results				
Inspection Date	X	X	X	
SSC Condition	X	X		
Logs	X	X	X	

Basis: Documentation of the parameters listed in Table 9-1 above satisfies the requirements of LPR 230-07-00, Criteria 2, (Ref. 10.20) which states; "Maintenance activities, equipment problems, and inspection and test results are documented."

10.0 REFERENCES

The following references and associated revisions were used in the development of this document.

- 10.1** LIR 230-05-01.0, "Operation and Maintenance Manual."
- 10.2** DOE Order 430.1A, Attachment 2, "*Contractor Requirements Document*," (paragraph 2, sections A through C), a requirement of Appendix G of the UC Contract.
- 10.3** DOE Order 4330.4B: Maintenance Management Program.
- 10.4** LIR 301-00-02.0, "Exceptions or Variance to Laboratory Operation Requirements."
- 10.5** IEEE 446-1995: Recommended Practice for Emergency and Standby Power systems for Industrial and Commercial Applications.
- 10.6** IEEE 100-1996: Standard Dictionary of Electrical and Electronic Terms.

- 10.7** IEEE 450-1995: Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
- 10.8** NFPA 70B-1998: Electrical Equipment Maintenance.
- 10.9** NFPA 110-1999: Emergency and Standby Power Systems.
- 10.10** DOE STD 3003-2000: Backup Power Sources for DOE facilities.
- 10.11** IEEE 1106-1995: Recommended Practice for Maintenance, Testing, and Replacement of Nickel-cadmium Storage Batteries for Generating Stations and Substations.
- 10.12** IEEE-1188-1996: Recommended Practice for Maintenance, Testing, and Replacement of Valve-regulated Lead-acid Batteries for Stationary Applications.
- 10.13** NFPA-111-1996: Stored Electrical Energy Emergency and Standby Power Systems.
- 10.14** LANL Criterion 503-Rev. 0: Emergency Lighting Systems.
- 10.15** LANL Criterion 505-Rev. 0: Uninterruptible Power Supply Systems.
- 10.16** LANL Criterion 506-Rev. 0: Emergency and Standby Power Systems.
- 10.17** JCNNM PMI 40-10-010-Rev. 0: Nickel-cadmium Battery Bank Preventive Maintenance and Inspection.
- 10.18** JCNNM PMI 40-10-003-Rev. 1: Battery Bank Preventive Maintenance and Inspection.
- 10.19** Code of Federal Regulations 29 CFR 1926.441: Safety and Health Regulations for Construction, Batteries and Battery Charging.
- 10.20** LPR 230-07-00.0, Maintenance History, Performance Criteria 2.

11.0 APPENDICES

- Appendix A:** Battery Maintenance Inspection Requirements and Schedule, Vented Lead-Acid Cells
- Appendix B:** Battery Maintenance Inspection Requirements and Schedule, Valve-Regulated Lead-Acid Cells.
- Appendix C:** Battery Maintenance Inspection Requirements and Schedule, Vented Nickel-Cadmium Cells
- Appendix D:** Standards for Selection of Safety Equipment

APPENDIX A
Battery Maintenance Inspection Requirements and Schedule
Vented Lead-Acid Cells

Maintenance Task	Frequency			Failure Criterion (4)
	Level 1	Level 2	All Others	
Visual Inspection:				
General appearance: battery/rack/area	W	W	M	<i>Loose Connections Noted</i>
Dirt/electrolyte on jars/covers, etc.	W	W	M	<i>Excessive Dirt Noted on Cells or Connectors</i>
Charger output voltage/current	W	W	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Electrolyte level	W	W	M	<i>Electrolyte Reaches Low-Level Line</i>
Jar/cover cracks or leaks	W	W	M	<i>Leak Noted</i>
Evidence of corrosion	W	W	M	<i>Terminal Corrosion Noted</i>
Flame arrester	A	A	A	<i>Clog Noted</i>
Detailed rack inspection	A	A	A	<i>Rack Connection Loose, Broken Parts</i>
Insulating covers on racks	A	A	A	<i>Missing or Broken Covers</i>
Seismic rack parts/spacers	A	A	A	<i>Missing or Broken Parts/Spacers</i>
Detailed cell inspection:				
Plates: cracks/ sulfate/hydration	A	A	A	<i>Cracks, Sulfate, Hydration Noted</i>
Abnormal sediment accumulation	A	A	A	<i>Abnormal Sediment Accumulation Noted</i>
Jar and post seals	A	A	A	<i>Seals Broken</i>
Jar/Cover	A	A	A	<i>Excessive Jar/Cover Distortion</i>
Gassing	A	A	A	<i>Off-Gas Levels Above Manufacturer's Recommended Limits</i>
Signs of vibration	A	A	A	<i>Loose Connections/Damage Noted</i>

APPENDIX A (cont'd) Battery Maintenance Inspection Requirements and Schedule Vented Lead-Acid Cells				
Maintenance Tasks	Frequency			Failure Criterion (4)
	Level 1	Level 2	All Others	
Measurements:				
Battery float voltage	M	M	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Pilot cell voltage	M	M	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Pilot cell electrolyte temperature	M	M	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Pilot cell electrolyte specific gravity	M	M	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Individual cell voltage	Q	Q	Q	<i>Outside of Manufacturer's Recommended Operating Range</i>
Individual cell electrolyte specific gravity	Q(1) A	Q(1) A	Q(1) A	<i>Outside of Manufacturer's Recommended Operating Range</i>
Cell temperature	Q(1) A	Q(1) A	Q(1) A	<i>Cell Temperatures Deviate More than 5 Degrees F Between Cells</i>
Intercell connection resistance	A	A	A	<i>Resistance Readings are More than 20% above the Installation Value or Above Manufacturer's Ceiling Value</i>

APPENDIX A (cont'd) Battery Maintenance Inspection Requirements and Schedule Vented Lead-Acid Cells				
Maintenance Tasks	Frequency			Failure Criterion (4)
	Level 1	Level 2	All Others	
Tests:				
Service Test	Q	A	A	<i>Inability of battery to carry required load for entire duty cycle</i>
Performance Test	A	2 yrs (3) 5 yrs (2)	2 yrs (3) 5 yrs (2)	<i>Battery Capacity is below manufacturer's rating for the design basis</i>
Other				
Ambient temperature	M	M	M	<i>N/A (Record this Value)</i>
Ventilation equipment adequacy	M	M	M	<i>N/A (Record Observations)</i>
Check/Retorque battery rack	A	A	A	<i>Connections do not Meet Manufacturer's Torque Values</i>
Check connections to ground	A	A	A	<i>Loose Connections Noted. Ground Resistance Reading Greater than 10 Ohms.</i>

W – Weekly

M – Monthly

Q – Quarterly

A – Annually

5 yrs – Every 5 years

Note: DOE 4330.4B (para. 5.2 & 7.3.3a) (Ref. 10.10) allows a 25% grace period for missed time intervals unless other site-specific requirements are given.

- (1) Check 10% of cells
- (2) Should excessive capacity loss (90% of manufacturer's rating) be noted or upon reaching 85% of service life, revert to annual testing. *Basis:* IEEE 450, Section 6.4. (Reference 10.3)
- (3) First test two years after installation. *Basis:* IEEE 450, Section 5.2a (Reference 10.3)
- (4) Perform corrective actions as follows:
 - For Level 1 or Level 2 batteries, repair or replace prior to placing back in service
 - For All Other Batteries, repair or replace. When replacement is required, the recommended maximum time for replacement is one year per IEEE 450, Section 7. (Reference 10.3).

APPENDIX B
Battery Maintenance Inspection Requirements and Schedule
Valve-Regulated Lead-Acid Cells

Maintenance Tasks	Frequency			Failure Criterion (4)
	Level 1	Level 2	All Others	
Visual Inspection:				
General appearance: battery/rack/area	W	W	M	<i>Loose Connections Noted</i>
Dirt/electrolyte on jars/covers, etc.	W	W	M	<i>Excessive Dirt Noted on Cells or Connectors</i>
Charger output voltage/current	W	W	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Jar/cover cracks or leaks	W	W	M	<i>Leak Noted</i>
Evidence of corrosion	W	W	M	<i>Terminal Corrosion Noted</i>
Detailed rack inspection	A	A	A	<i>Rack Connection Loose, Broken Parts</i>
Insulating covers on racks	A	A	A	<i>Missing or Broken Covers</i>
Seismic rack parts/spacers	A	A	A	<i>Missing or Broken Parts/Spacers</i>
Jar and post seals	M	M	M	<i>Seals Broken</i>
Jar/Cover	M	M	M	<i>Excessive Jar/Cover Distortion</i>
Signs of vibration	A	A	A	<i>Loose Connections/Damage Noted</i>

APPENDIX B (cont'd) Battery Maintenance Inspection Requirements and Schedule Valve-Regulated Lead-Acid Cells				
Maintenance Tasks	Frequency			Failure Criterion (4)
	Level 1	Level 2	All Others	
Measurements:				
Battery Float Voltage	M	M	M	<i>Outside of Manufacturer's Recommended Operating Range</i>
Individual cell voltage	S	S	S	<i>Outside of Manufacturer's Recommended Operating Range</i>
Cell temperature	Q (1)	Q (1)	Q (1)	<i>Cell Temperatures Deviate More than 5 Degrees F Between Cells</i>
Intercell connection resistance	Q (2) A	Q (2) A	Q (2) A	<i>Resistance Readings are More than 20% Above the Installation Value or Above Manufacturer's Ceiling Value</i>
Cell impedance/conductance/resistance	Q	Q	Q	<i>Cell/Unit Internal Ohmic Values Deviate by 20% from Either the Installation Value or Average of All Cells/Units</i>
AC ripple current/ voltage	A	A	A	<i>Outside of Manufacturer's Recommended Operating Range</i>

APPENDIX B (cont'd) Battery Maintenance Inspection Requirements and Schedule Valve-Regulated Lead-Acid Cells				
Maintenance Tasks	Frequency			Failure Criterion (4)
Tests:	Level 1	Level 2	All Others	
Performance Test	A (3)	A (3)	A (3)	<i>Battery Capacity is below manufacturer's rating for the design basis</i>
Service Test	Q	A	A	<i>Inability of battery to carry required load for entire duty cycle</i>
Other				
Ambient temperature	M	M	M	<i>N/A (Record this Value)</i>
Ventilation equipment adequacy	M	M	M	<i>N/A (Record Observations)</i>
Check/retorque battery rack	A	A	A	<i>Connections do not Meet Manufacturer's Torque Values</i>
Check connections to ground	A	A	A	<i>Loose Connections Noted. Ground Resistance Reading Greater than 10 Ohms.</i>

W – Weekly

M – Monthly

Q – Quarterly

S – Semiannually

A - Annually

5 yrs – Every 5 years

- (1) Measure temperature at the negative terminal of each cell module.
- (2) Sample 25% per quarter. If sample shows an increase in resistance, perform measurements on each connection.
- (3) Should excessive capacity loss (90% of manufacturer's rating) be noted, revert to semiannual testing. *Basis:* IEEE 1188, Section 6.3. (Reference 10.8)
- (4) Perform corrective actions as follows:
 - For Level 1 or Level 2 batteries, repair or replace prior to placing back in service
 - For All Other batteries, repair or replace. When replacement is required, the recommended maximum time for replacement is one year per IEEE 450, Section 7. (Reference 10.3).

APPENDIX C
Battery Maintenance Inspection Requirements and Schedule
Vented Nickel-Cadmium Cells

Maintenance Task	Level	Level 2	All Others	Failure Criterion (2)
Visual Inspection				
General appearance: battery/rack/area	W	W	Q	<i>Loose Connections Noted</i>
Dirt/electrolyte on jars/covers, etc.	W	W	Q	<i>Excessive Dirt Noted on Cells or Connectors</i>
Charger output voltage/current	W	W	Q	<i>Outside of Manufacturer's Recommended Operating Range</i>
Electrolyte level	W	W	Q	<i>Cell Electrolyte Reaches Low-Level Line</i>
Jar/cover cracks or leaks	W	W	Q	<i>Leak Noted</i>
Evidence of corrosion	W	W	Q	<i>Terminal Corrosion Noted</i>
Flame arrester	A	A	A	<i>Clog Noted</i>
Detailed rack inspection	A	A	A	<i>Rack Connection Loose, Broken Parts</i>
Insulating covers on racks	A	A	A	<i>Missing or Broken Covers</i>
Seismic rack parts/spacers	A	A	A	<i>Missing or Broken Parts/Spacers</i>
Jar and post seals	A	A	A	<i>Seals Broken</i>
Measurements				
Battery float voltage	Q	Q	Q	<i>Outside of Manufacturer's Recommended Operating Range</i>
Pilot cell electrolyte temperature	Q	Q	Q	<i>Outside of Manufacturer's Recommended Operating Range</i>

APPENDIX C (cont'd) Battery Maintenance Inspection Requirements and Schedule Vented Nickel-Cadmium Cells				
Maintenance Task	Level 1	Level 2	All Others	Failure Criterion (2)
Measurements (cont'd)				
Individual cell voltage	S	S	S	<i>Outside of Manufacturer's Recommended Operating Range</i>
Intercell connection torque	A	A	A	<i>Outside of Manufacturer's Recommended Values</i>
Tests				
Performance Test	A	5 yrs (1)	5 yrs (1)	<i>Battery Capacity is Below Manufacturer's Rating for the Design Basis</i>
Service Test	Q	A	A	<i>Inability of Battery to Carry Required Load for Entire Duty Cycle</i>
Other				
Ventilation equipment adequacy	Q	Q	Q	<i>N/A (Record Observations)</i>
Check/Retorque battery rack	A	A	A	<i>Loose Connections Noted</i>
Check connections to ground	A	A	A	<i>Loose Connections Noted. Ground Resistance Reading Greater than 10 Ohms.</i>

W – Weekly

M – Monthly

Q – Quarterly

S – Semiannually

A - Annually

5 yrs – Every 5 years

(1) Should excessive capacity loss (1.5% per year) be noted, revert to annual testing.

Basis: IEEE 1106, Section 8.2. (Reference 10.7).

(2) Perform corrective actions as follows:

- For Level 1 or Level 2 batteries, repair or replace prior to placing back in service
- For All Other Batteries, repair or replace. When replacement is required, the recommended maximum time for replacement is one year per IEEE 450, Section 7. (Reference 10.3)

APPENDIX D

STANDARDS FOR SELECTION OF SAFETY EQUIPMENT

ISEA Z89.1	Industrial Head Protection
ANSI Z87.1A	Practice for Occupational and Educational Eye and Face Protection
ASTM D1048	Standard Specification for Rubber Insulating Blankets
ASTM D1049	Standard Specification for Rubber Insulating Covers
ASTM D1051	Standard Specification for Rubber Insulating Sleeves
ASTM D120	Standard Specification for Rubber Insulating Gloves
ASTM D178	Standard Specification for Rubber Insulating Matting
ASTM F1505	Standard Specification for Insulated and Insulating Hand Tools
ASTM F696	Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens
NSC Z41	Protective Footwear
ISEA Z358.1	Emergency Eyewash and Shower Equipment <i>Note: ANSI Z358.1 withdrawn</i>